Beta-decay study of neutron-rich manganese isotopes around N=40

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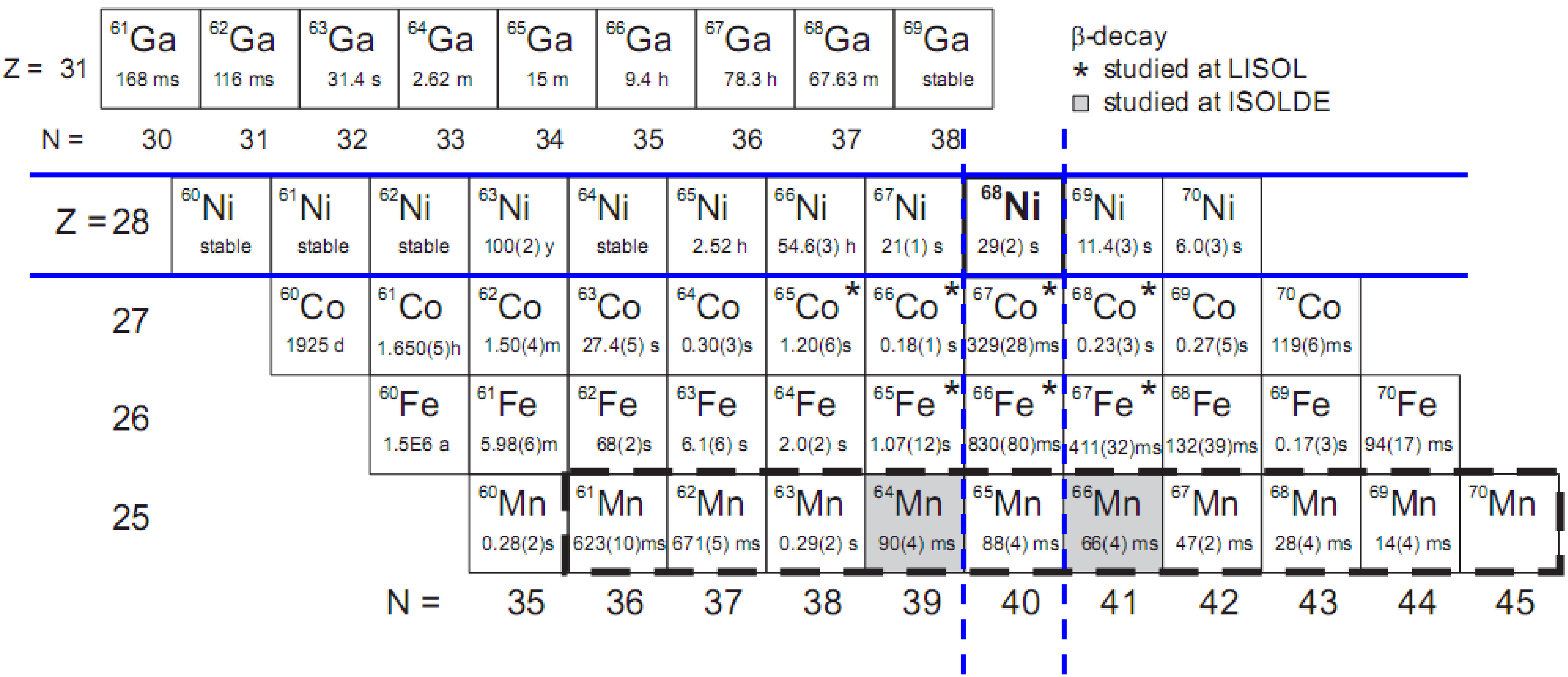
Outline

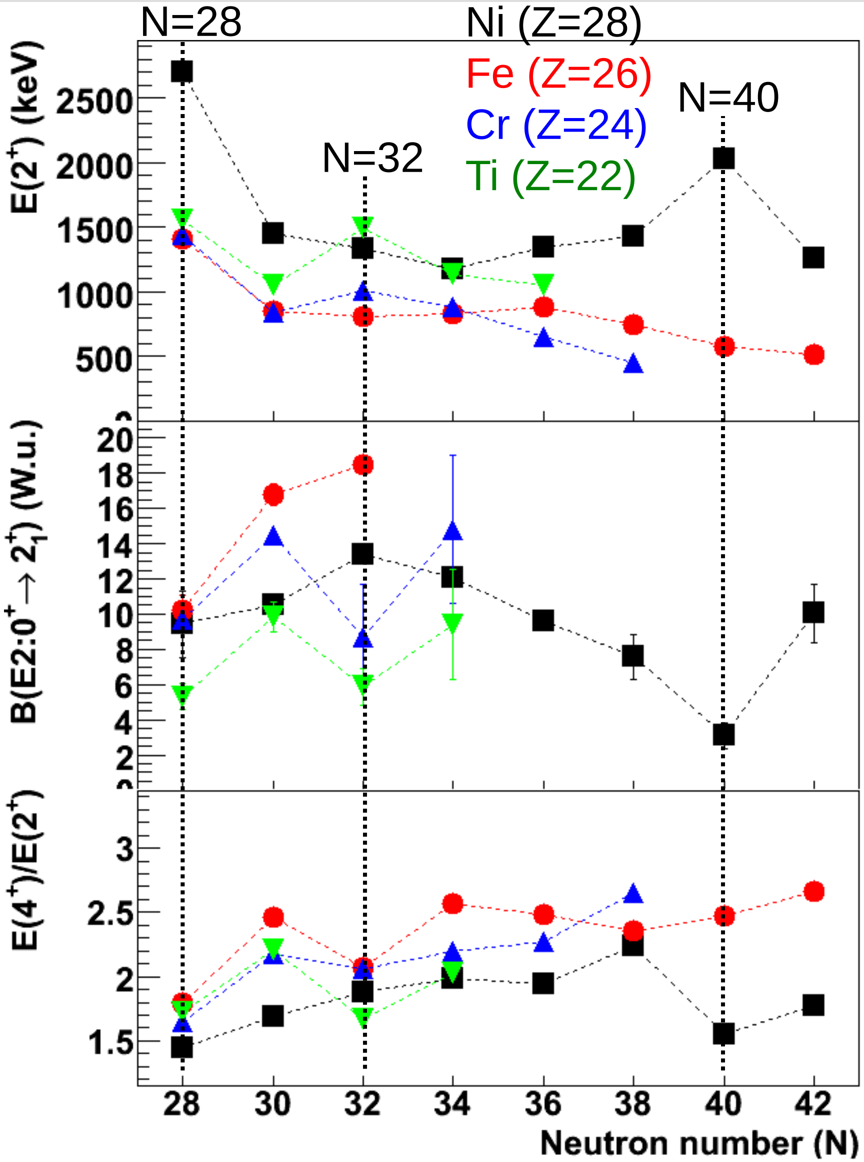
- Motivation
- Experimental setup
- Results: focus on ^{66}Mn decay (chain)
- Conclusions and outlook

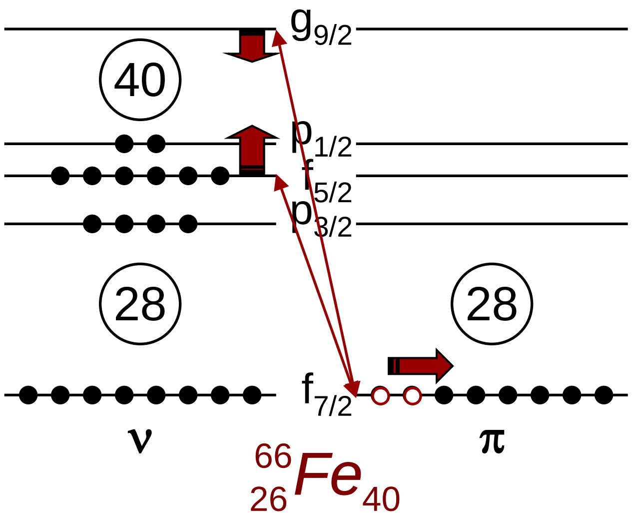
Beta decay of neutron-rich Mn isotopes



Studying the Z<28, N~40 region

The Z<28, N~40 region: systematics





T. Otsuka et al., PRL **95**, 232502 (2005)

$\pi f_{5/2}$ monopole migration (N=32 isotones):

*R.V.F. Janssens et al., PLB **546***

Enhanced collectivity in Fe isotopes towards N=40:

*M. Hannawald et al., PRL **82***

*S. Lunardi et al., PRC **76***

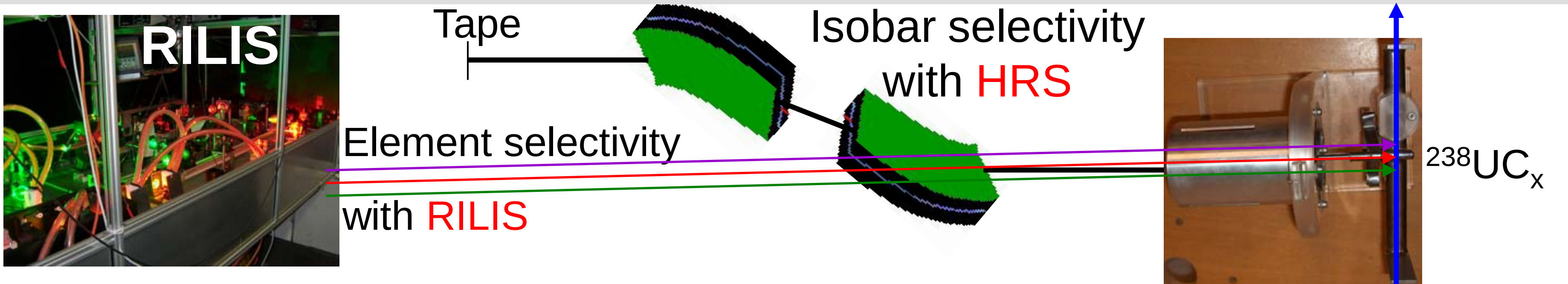
Development of large deformation in ^{62,64}Cr:

*O. Sorlin et al., EPJA **16***

*N. Aoi et al., PRL **102***

*P. Adrich et al., PRC **77***

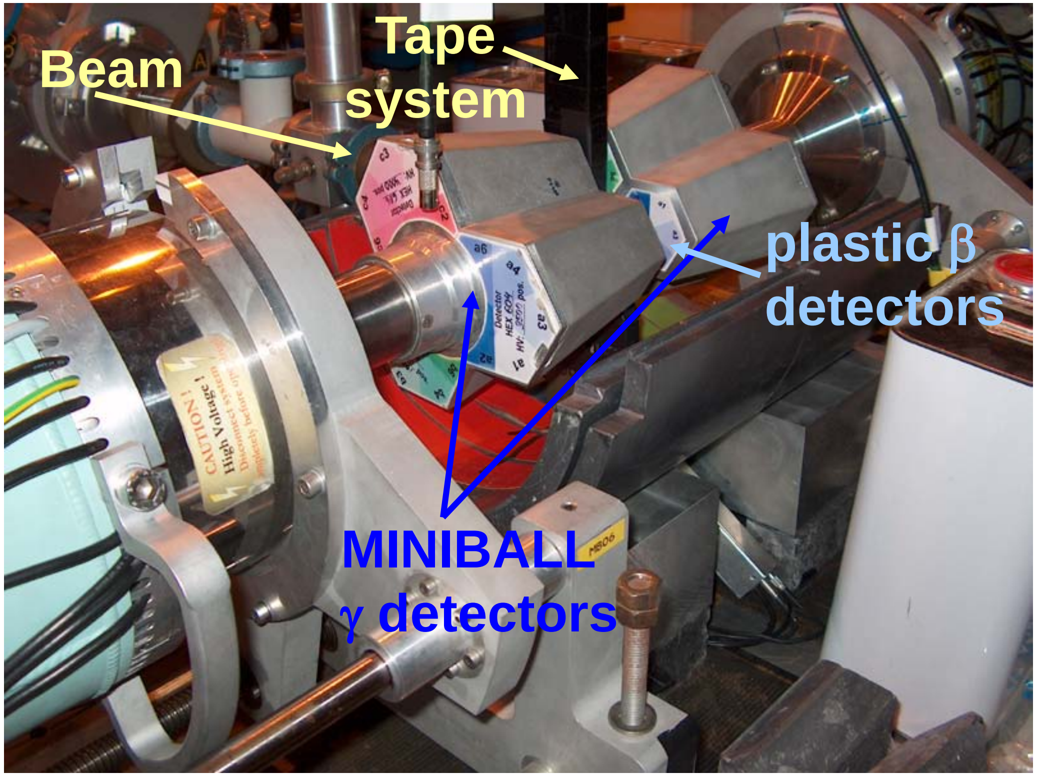
Production of Mn isotopes

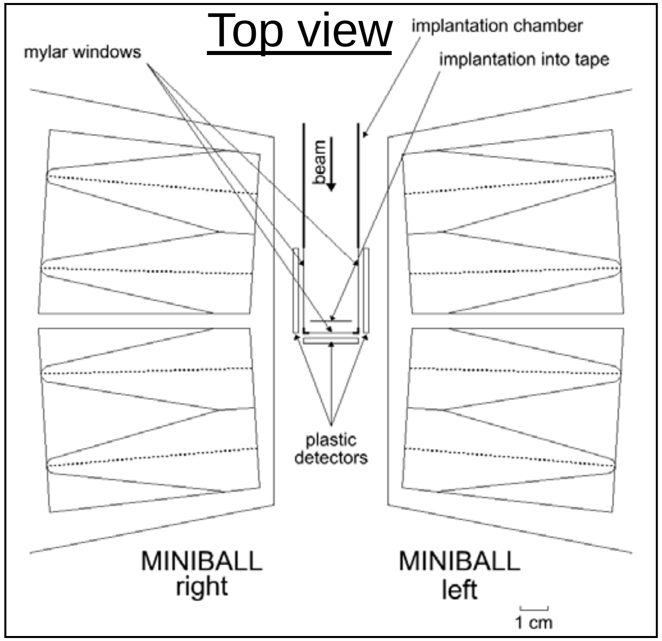


Z \ N	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Z = 31	^{61}Ga 168 ms	^{62}Ga 116 ms	^{63}Ga 31.4 s	^{64}Ga 2.62 m	^{65}Ga 15 m	^{66}Ga 9.4 h	^{67}Ga 78.3 h	^{68}Ga 67.63 m	^{69}Ga stable							
Z = 28			^{60}Ni stable	^{61}Ni stable	^{62}Ni stable	^{63}Ni 100(2) y	^{64}Ni stable	^{65}Ni 2.52 h	^{66}Ni 54.6(3) h	^{67}Ni 21(1) s	**^{68}Ni** 29(2) s	^{69}Ni 11.4(3) s	^{70}Ni 6.0(3) s			
27				^{60}Co 1925 d	^{61}Co 1.650(5)h	^{62}Co 1.50(4)m	^{63}Co 27.4(5) s	^{64}Co 0.30(3)s	^{65}Co * 1.20(6)s	^{66}Co * 0.18(1) s	^{67}Co * 329(28)ms	^{68}Co * 0.23(3) s	^{69}Co 0.27(5)s	^{70}Co 119(6)ms		
26					^{60}Fe 1.5E6 a	^{61}Fe 5.98(6)m	^{62}Fe 68(2)s	^{63}Fe 6.1(6) s	^{64}Fe 2.0(2) s	^{65}Fe * 1.07(12)s	^{66}Fe * 830(80)ms	^{67}Fe * 411(32)ms	^{68}Fe 132(39)ms	^{69}Fe 0.17(3)s	^{70}Fe 94(17) ms	
25				^{58}Mn 3.0(1)s		^{60}Mn 0.28(2)s	^{61}Mn 623(10)ms	^{62}Mn 671(5) ms	^{63}Mn 0.29(2) s	^{64}Mn 90(4) ms	^{65}Mn 88(4) ms	^{66}Mn 66(4) ms	^{67}Mn 47(2) ms	^{68}Mn 28(4) ms	^{69}Mn 14(4) ms	^{70}Mn

β-decay
* studied at LISOL
□ studied at ISOLDE

LISOL detection setup at ISOLDE



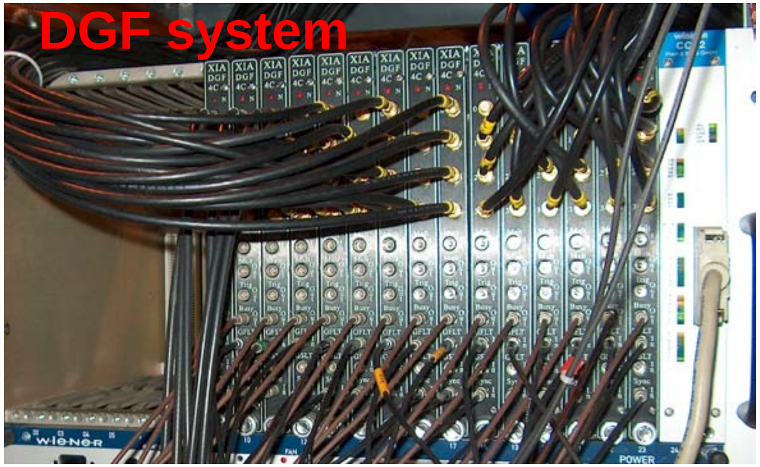


MINIBALL: 5.8% photo-peak efficiency at 1.332 MeV

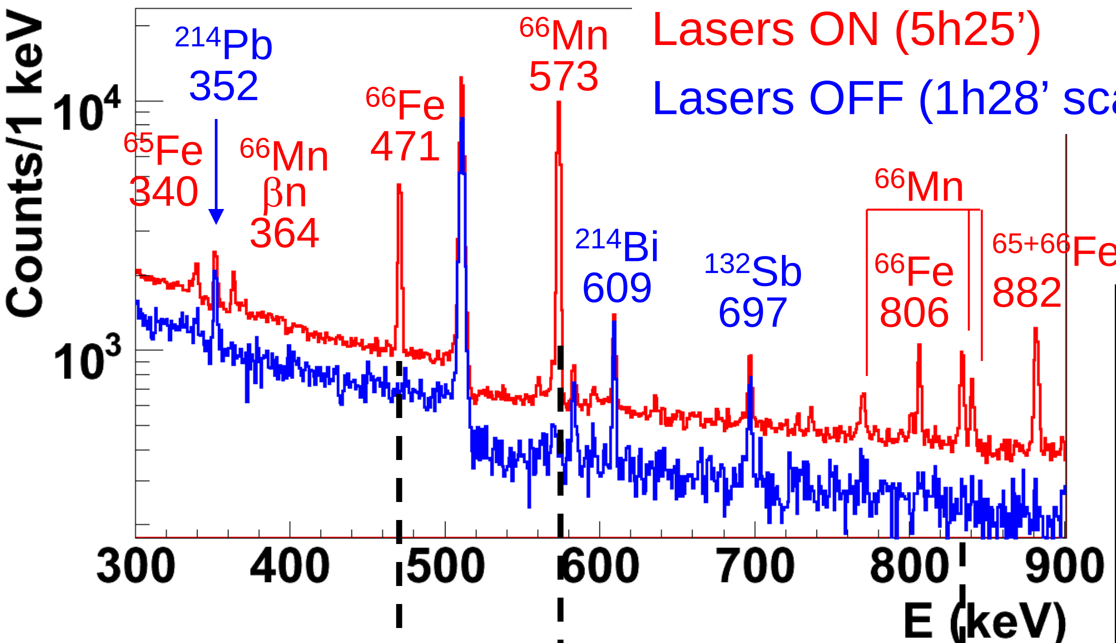
3 plastic detectors: 50% beta efficiency

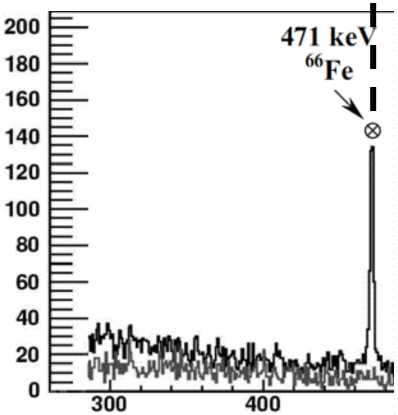
DGF system: digital read-out on event-by-event basis

Polyethylene-borax-lead-brass shielding

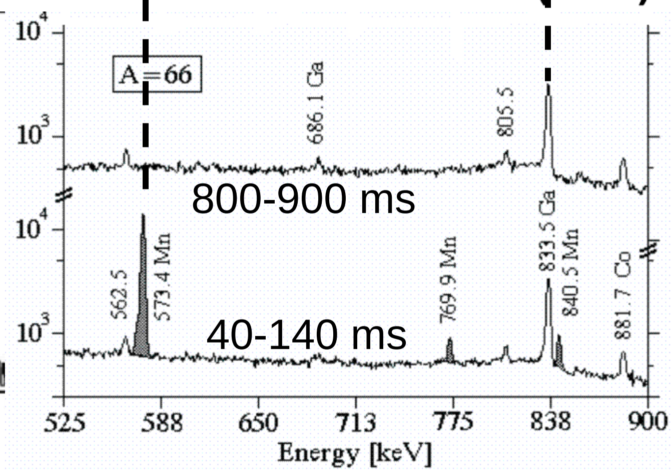


^{66}Mn decay





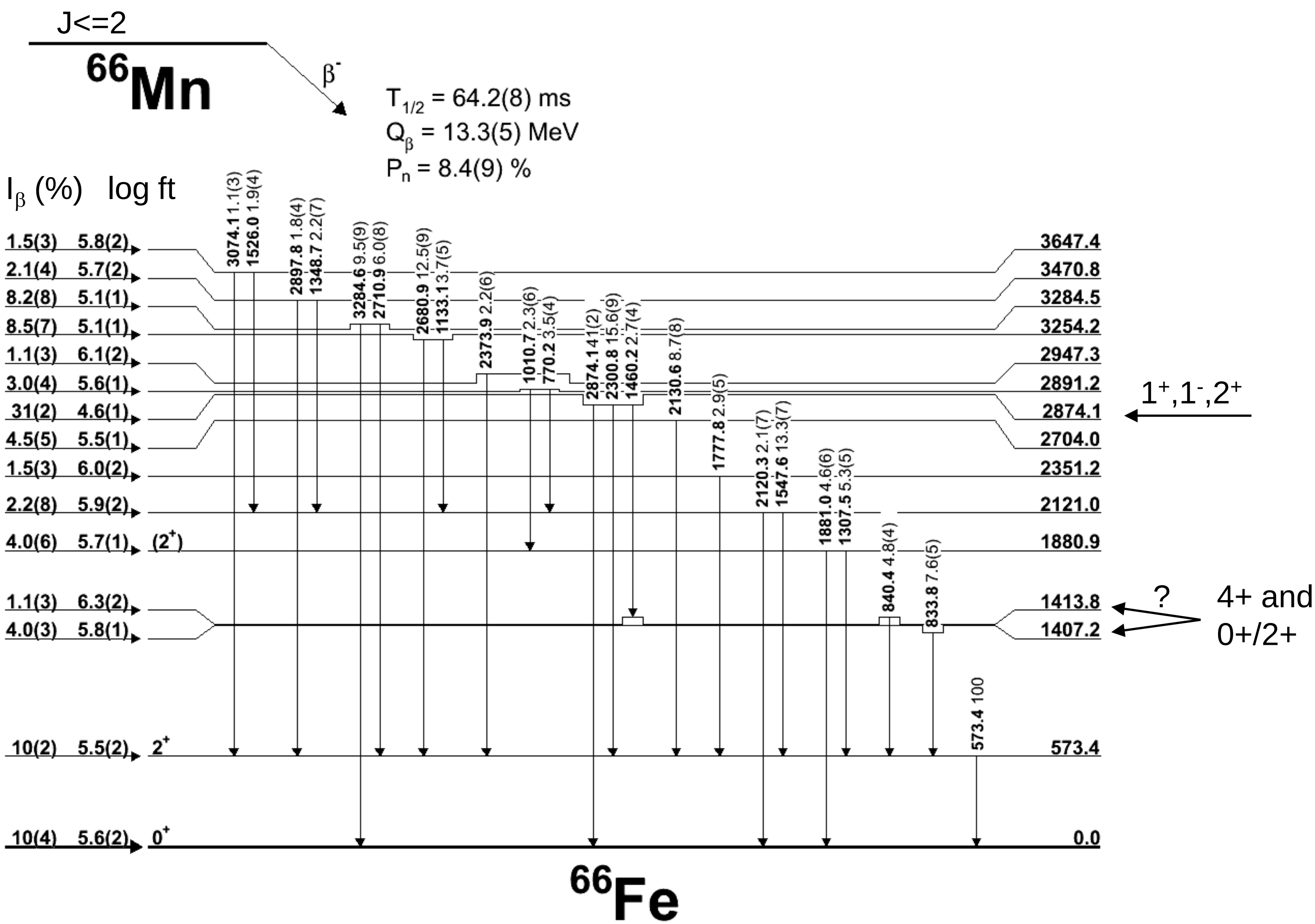
O. Ivanov, Ph.D., Leuven (2007)



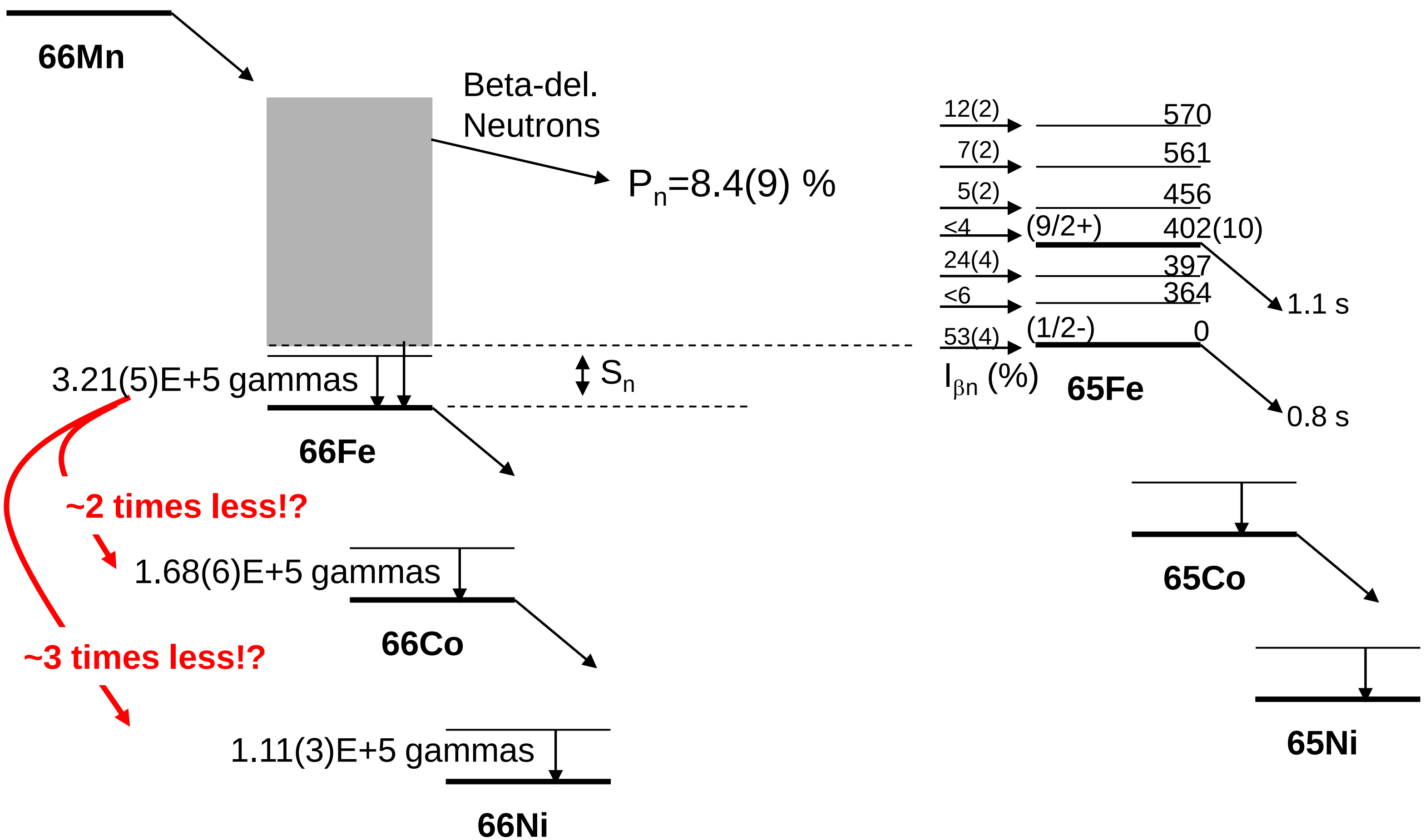
M. Hannawald, Ph.D., Mainz (2000)

- PURE Mn SPECTRA
  - ➢ Low background (shielding)
  - ➢ RILIS
  - ➢ High mass-resolving power (HRS)
- (GRAND)DAUGHTER INFORMATION
  - ➢ Often much more statistics than in previous studies
  - ➢ Check of beta-branching ratios
- BETA-DELAYED NEUTRON BRANCHES
  - ➢ Extra info for J^π determinations
- Mn HALF-LIVES

^{66}Mn decay into ^{66}Fe



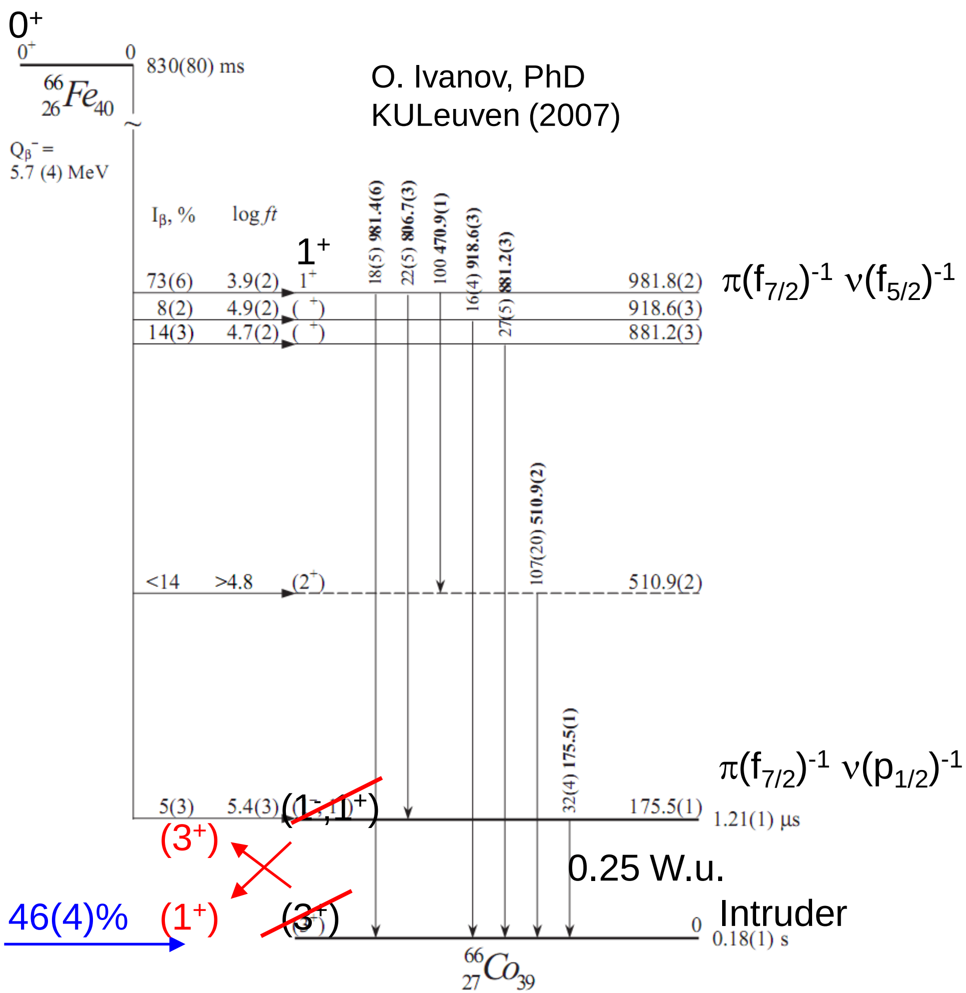
^{66}Mn decay chain



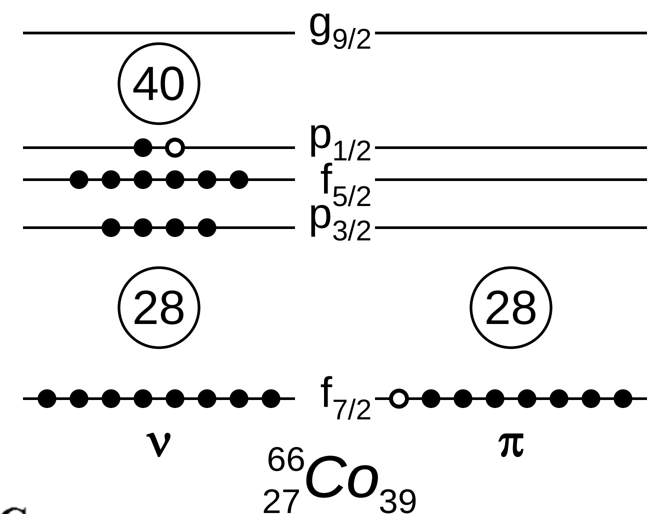
How to explain missing gamma activity?

Direct gs feeding and/or $0^+ \rightarrow 0^+$ monopole transitions

^{66}Mn daughter decays: ^{66}Fe and ^{66}Co



O. Ivanov, PhD
KULeuven (2007)



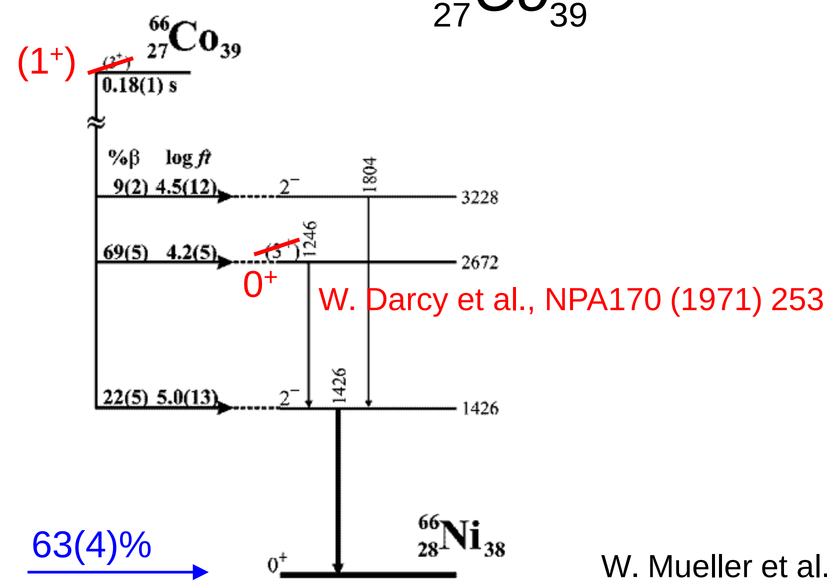
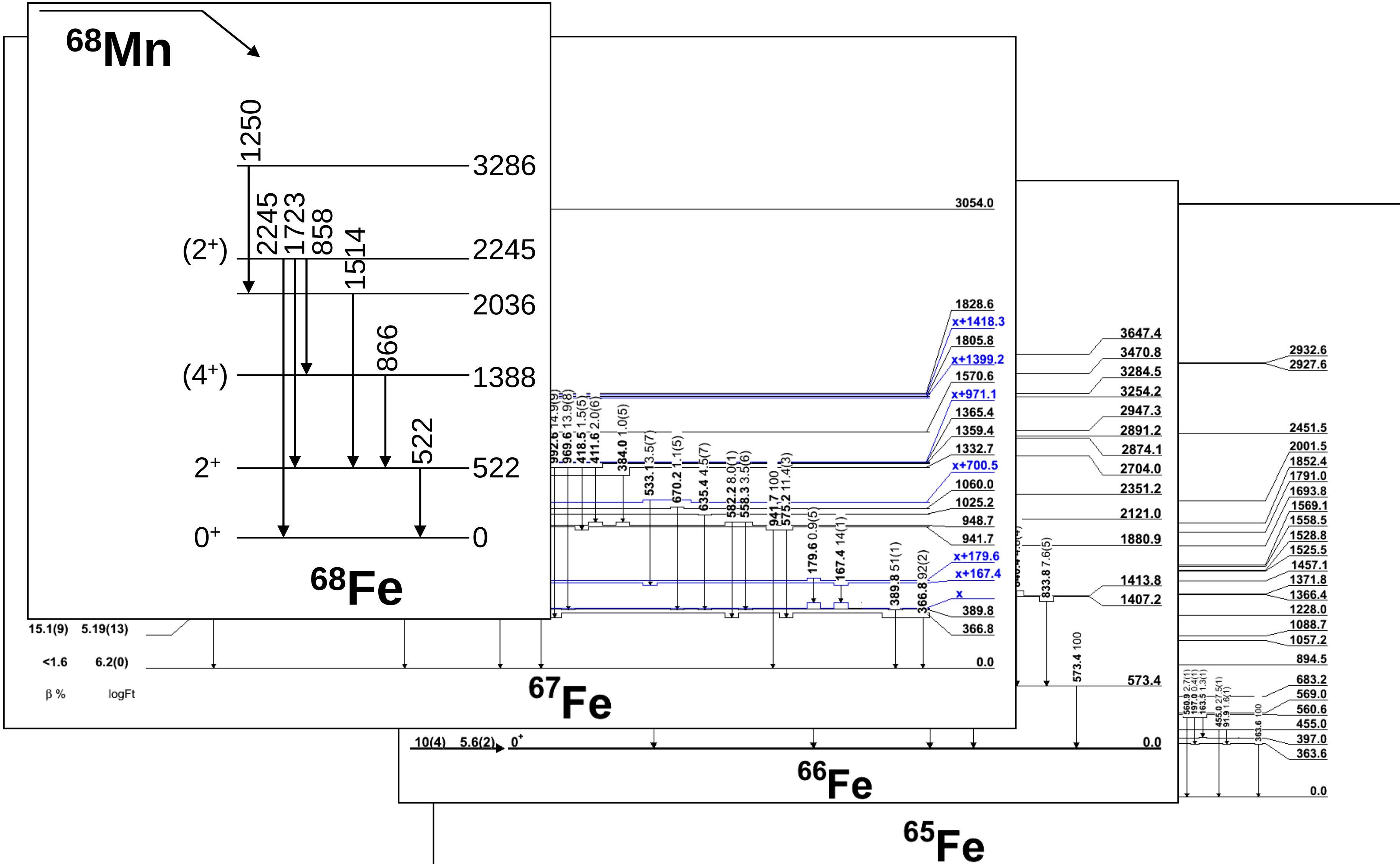


FIG. 4. The decay scheme for ^{66}Co.

W. Mueller et al.,
PRC61 (2000) 054308

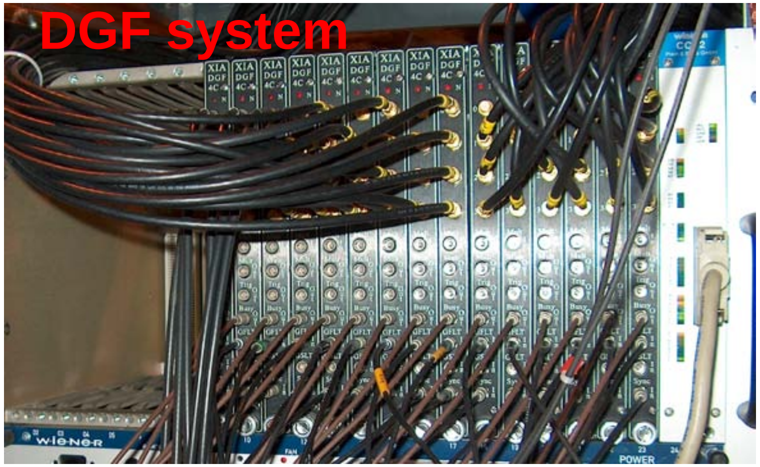
Status of the analysis



Conclusions and outlook

- Pure (RILIS + HRS) and intense $^{58,60\text{-}68}Mn$ beams produced at ISOLDE
- LISOL low-background $\beta\gamma$ setup with digital read-out
- Obtained wealth of data in the $^{58,60\text{-}68}Mn$ decay chains:
  - ✓ Mn (+ Fe and Co) decay schemes
  - ✓ I_β, $I_{\beta n}$, I_γ, and $T_{1/2}(\gamma)$: (J^π) to be determined
  - ✓ $T_{1/2}(\beta)$ values
  - ✓ P_n values
- First intruder discovered in the Z<28, N~40 region? (At Z=27, N=39!!!)
- Outlook
  - ✓ Finishing $^{65\text{-}67}Mn$-decay analysis
  - ✓ ^{68}Mn-decay data are being analyzed
  - ✓ Interpretation
  - ✓ Analysis of A<65 data

LISOL detection setup

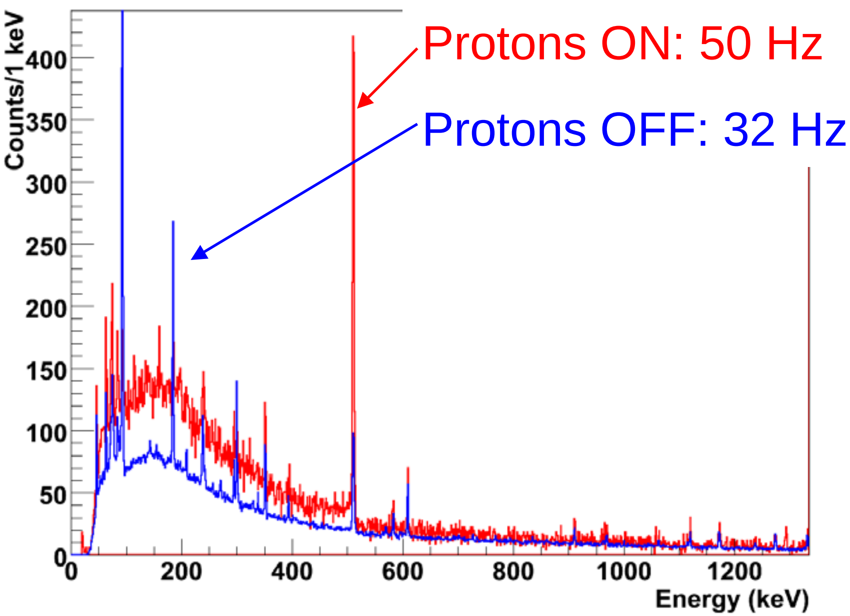


MINIBALL:
- 6 cores (no segments)
- Reducing true-coincidence summing

DGFs:
- Full data readout (E&T stamps)
- Coincidences and correlations off-line

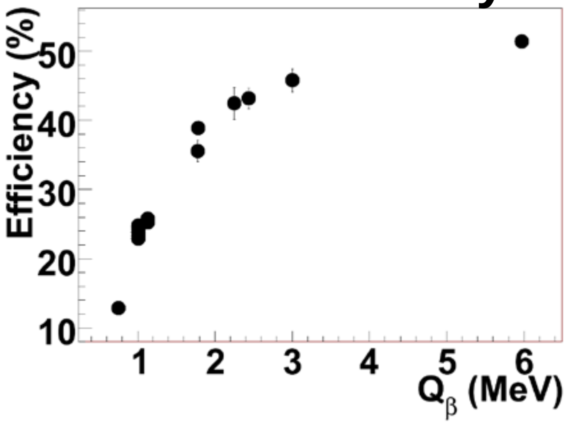
Shielding:
- low-background conditions

Singles-γ spectra: Background

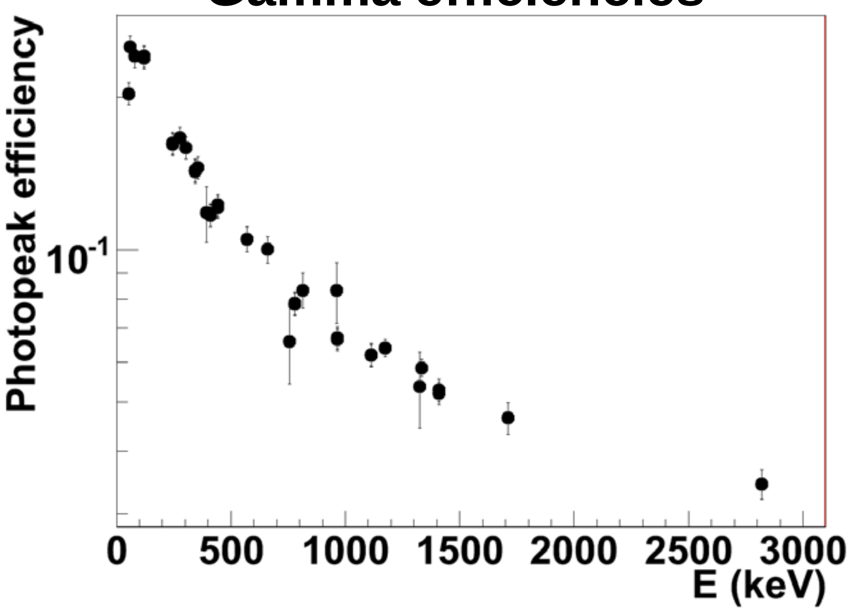


LISOL detection setup

Beta efficiency



Gamma efficiencies



Extracting gamma efficiencies

$$\varepsilon_\gamma = \frac{N_\gamma}{A_\gamma \cdot \Delta t \cdot I_\gamma} \cdot c_{summing}$$

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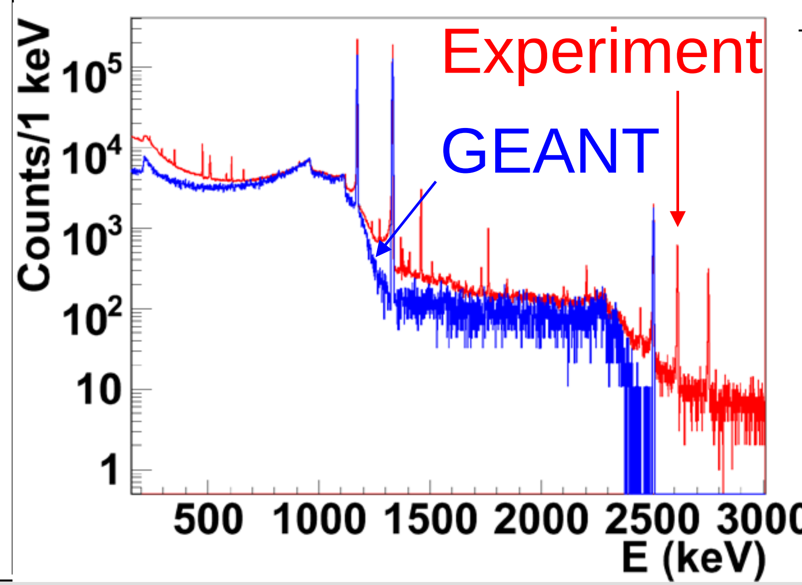
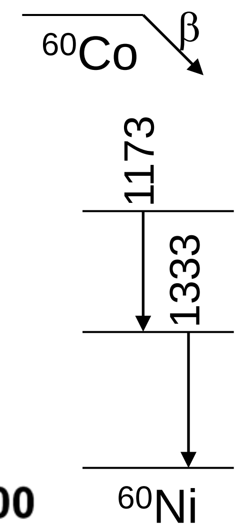
^{60}Co spectrum

- Observe the sum-peak at 2506 keV
- 1333 keV: 5% is summed

→ GEANT simulations

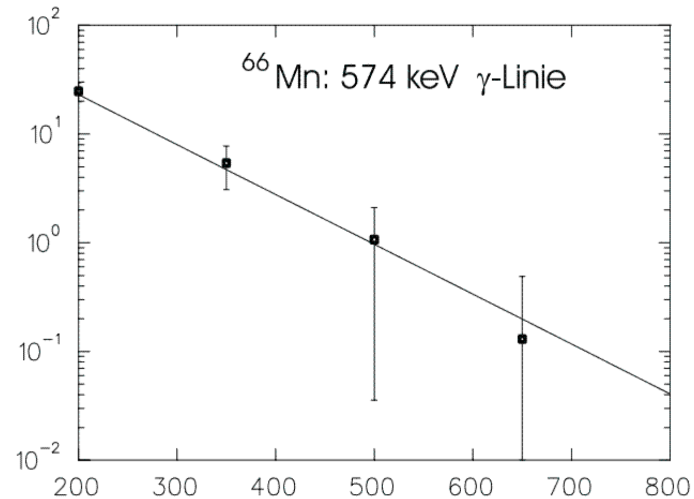


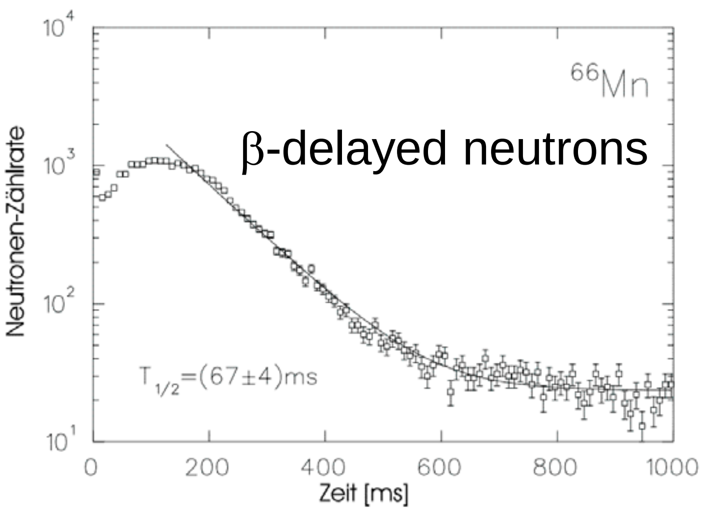


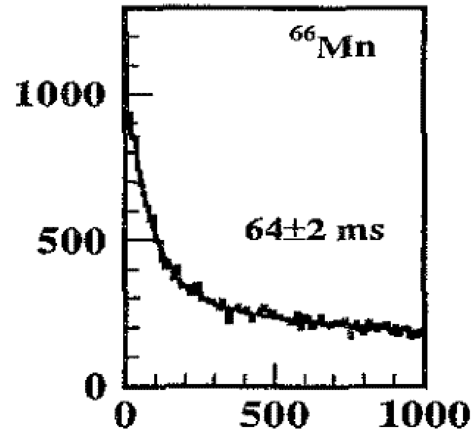
$T_{1/2}(^{66}Mn)$ (Preliminary)

M. Hannawald et al., PRL82 (1999) 1391

M. Hannawald, Ph.D. Thesis, Mainz (2000)





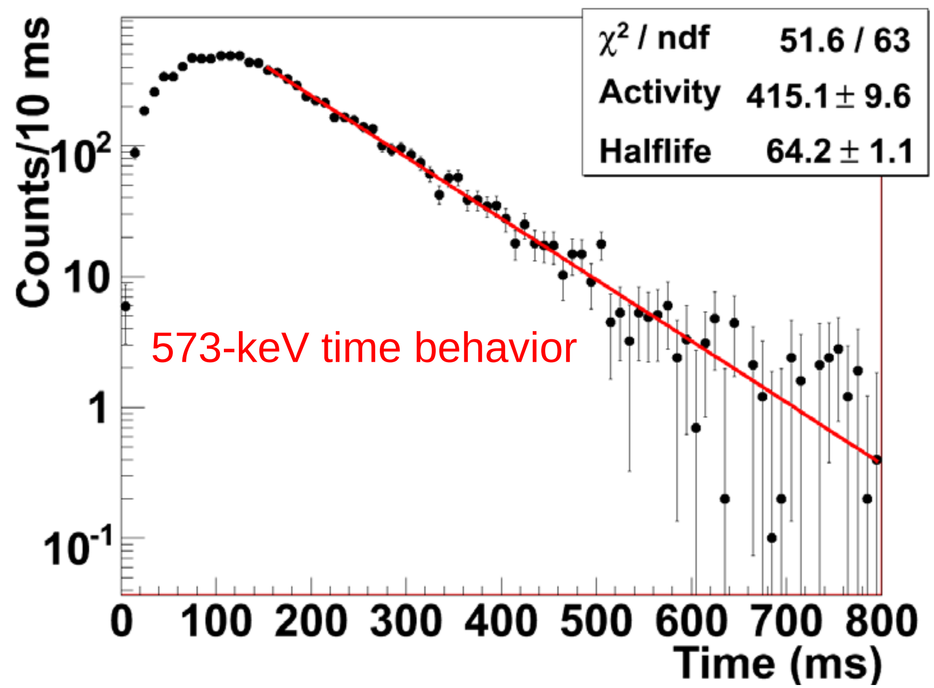


O. Sorlin et al., NPA719 (2003) 193c

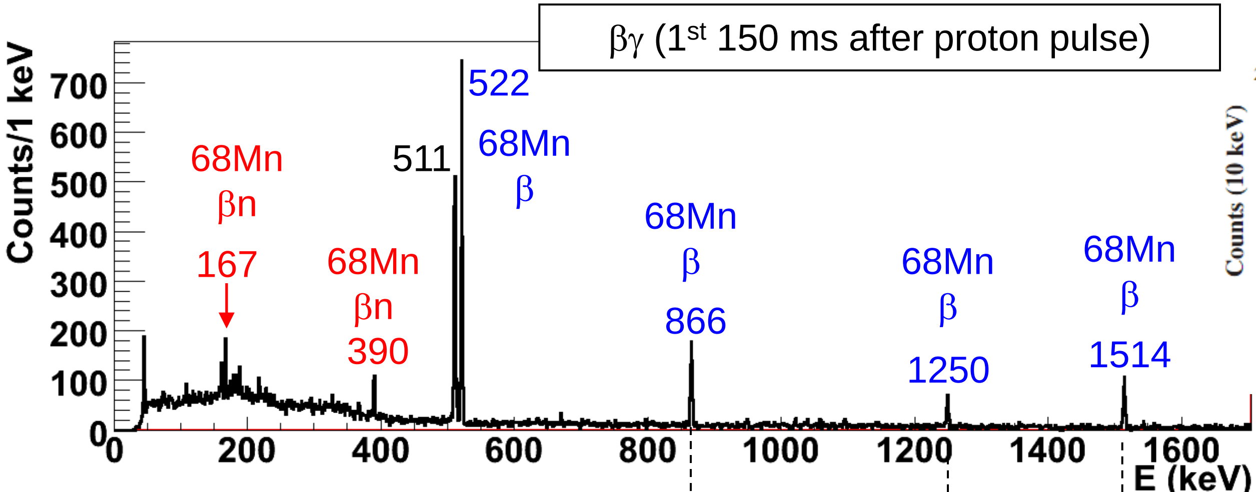
Fragmentation reaction: 61.8 A.MeV $^{76}Ge+^{58}Ni$

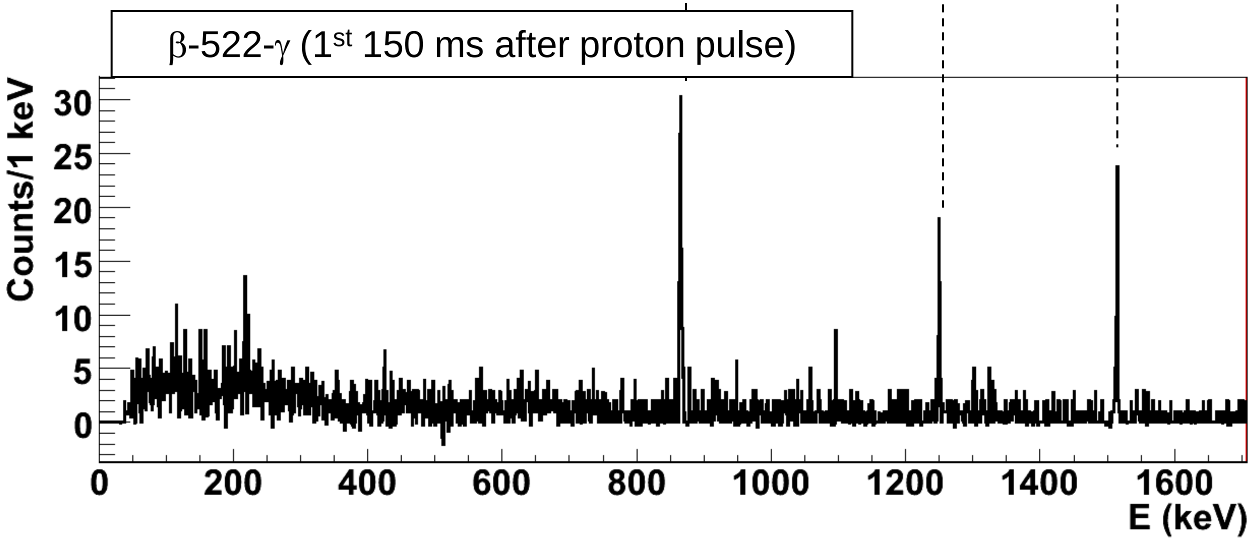
Active SSD stopper

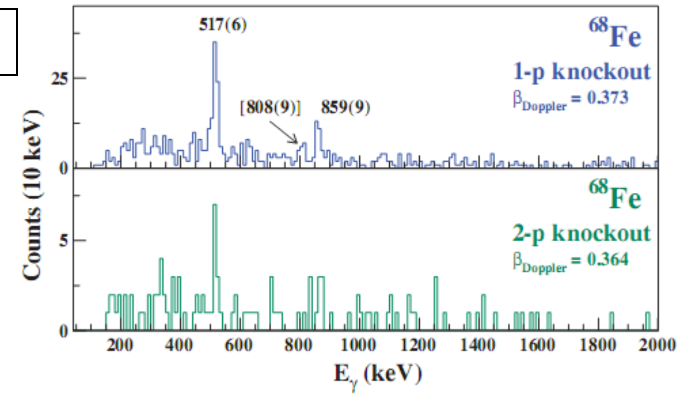
β-decay time spectra correlated with implants



^{68}Mn decay (preliminary)







Adrich et al., PRC77 ('08) 054306